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NASA NAVIGATOR Educator's Guide

Graphing Puzzles of Space Exploration

http://microgravity.grc.nasa.gov/outreach/navigator/game.html

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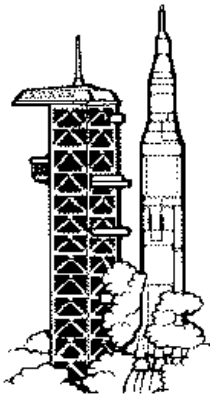
Grades 8-12

This abstract activity relies on understanding of inertial motion, as described by Newton's first law of motion.



Educational Objectives

The educational objectives of NASA Navigator are:

- to reinforce graphing skills,
- to reinforce understanding of gravity, forces & motion, and spaceflight,
- to provide a challenge requiring critical reasoning skills,
- to provide an opportunity for inquiry-based learning,
- to engage students through classroom competition.

Description

NASA Navigator is an educational activity for grades 8-12 that reinforces graphing skills and the understanding of gravity, forces and motion, and interplanetary spaceflight. The activity consists of two scored puzzle games:

- Planetary Probe (introductory game)
- Spaceship Commander

In both games, each player (or team) uses pencil and paper to plot the course of a spacecraft traveling through an imaginary system of planets. The puzzles are completed independently, and can be assigned as homework. There is no luck in the activity. Instead, critical reasoning skills are emphasized. As the spacecraft can be launched in any direction, each puzzle is open-ended and offers a multitude of correct solutions. Winners can be determined because the puzzles are scored for the science that can be accomplished for the plotted flight path. Classroom competition may further engage the interest of students.

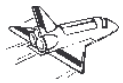
Despite the strong physics connection, this graphing activity does not require algebra or calculus. There are no equations to solve, and the most difficult math is the player's summation of their score. Nonetheless, the activity is abstract and challenging.

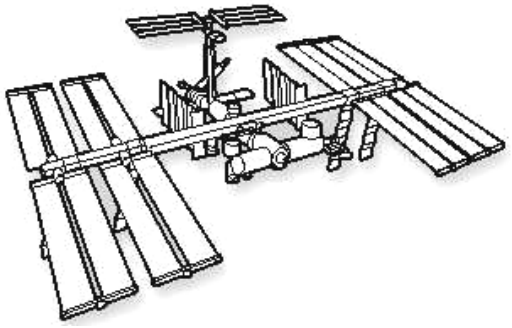
While the game realistically portrays how gravity causes the path of spacecraft to curve toward planets, the simplicity of the game prevents simulation of an orbit. In the game, it is not possible to get a spacecraft into orbit, where inertia and gravity alone cause the spacecraft to repeatedly circle a planet.

Planetary Probe - In this introductory game, the players must account for the effects of inertia and gravity on the flight path of an unmanned spacecraft. Points are earned when the spacecraft flies near planets to make remote measurements of their surface. The probe has no

engines, so thrust is not accounted for after launch. Therefore, the choice of the launch direction is the challenge in this game.

Spaceship Commander – In the full game, each player assumes the role of an astronaut and plots the course of a manned spaceship, accounting for effects of inertia, gravity, and thrust. Points are earned when their crew conducts planetary surveys and microgravity experiments. After a free launch, points are subtracted for each use of the engines, because that use means that additional fuel is required, which subsequently requires that the spaceship must be larger. As a result, players must carefully choose when and how to use the spaceship's engines.





Instruction

Although strongly grounded in realism, the puzzles that make up NASA Navigator are abstract and will likely challenge many students. Educators are strongly encouraged to start with the introductory Planetary Probe game before presenting the Spaceship Commander game to students, regardless of their grade level. The activity might be presented as part of a week-long series of classes, for example:

- Monday Review of gravity and forces & motions (e.g., Newton's laws)
- Tuesday Review of microgravity
- Wednesday Planetary Probe game introduction, plus homework
- Thursday Spaceship Commander game introduction, plus homework
- Friday In-class tournament

In this example, the first two days are used for a review of physics principles, while the last three days are dedicated to the NASA Navigator activity. If less time is available, it may be best to only present the Planetary Probe game, for example:

- Day 1 Review of gravity and forces & motions (i.e., Newton's First Law)
- Day 2 Planetary Probe game introduction, plus homework
- Day 3 In-class tournament

It should be understood that understanding of microgravity (apparent weightlessness) is not important for the Planetary Probe game. For the Spaceship Commander game, it is important that the students understand that the microgravity conditions are achieved during free fall, whenever the only (net) force on an object's motion is gravity. Therefore, in the vacuum of space, the astronauts within a coasting spaceship, where the engines are off, will experience apparent weightlessness regardless of the actual gravity. In contrast, if the engines are fired (and if the spaceship is spinning), the astronauts will experience apparent gravity. While a class period has been suggested to present and review microgravity concepts, the game can be played with just the understanding that microgravity points are earned when the spaceship's engines are off.

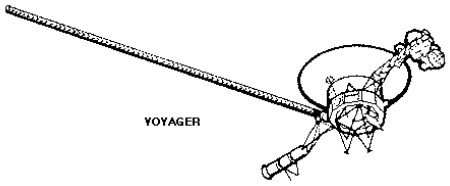
The NASA Navigator puzzles can be taught by example using transparencies, markers, and an overhead projector. Transparencies can be made of the provided system maps. The students must be provided with photocopies of the appropriate rule sheet(s) and maps. Both puzzle games can be taught by following the classroom lesson plan below:

- Introduce game basics,
  - using the provided presentation charts,
  - demonstrating basic spacecraft movement.
- Demonstrate a game,
  - where each student mimics the demonstration with pencil and eraser.
  - The students can be told to "Do what I do!"
- Students attempt assigned puzzle on their own or with partner(s),
  - on a specified map, with a specified home planet,
  - where the educator is available to address student questions.
  - Review sample solution if time is available.
- Assign homework
  - with specified map(s) and home planet(s).

For each puzzle assignment, the educator must specify both the map and the home (starting) planet, as these strongly influence the scores that might be achieved. This also simplifies any review and grading.

When assigning a Spaceship Commander puzzle, the educator must also specify the end turn. It is suggested that most games end at turn 10 or 15, because games of 20 turns can be challenging to review because the spacecraft might circle back and fly across the same section(s) of the map. Therefore, games of that length are recommended for experienced players, for example as an extra credit activity. The educator may also choose to assign Spaceship Commander puzzles with one or more of the optional rules listed at the bottom the puzzle maps. Note that the options in italics require use of the Advanced Rules Score Sheet and should only be assigned to experienced players. The "Limited Fuel" option should only be used with experienced players, but the other non-italic options such as "Race?" are appropriate for beginning players.

Erasers are critical for this activity, just as with a crossword puzzle. Students should be encouraged to erase turns and "do over" to improve their score, especially in the Spaceship Commander game.



Assigned puzzles can be graded for:

- proper labeling,
- proper spacecraft movement,
- proper completion of the movement log,
- proper scoring.

It should be recognized that there are 24 correct solutions for each Planetary Probe puzzle, for a specified home planet. The top-scoring solutions are available from the game designer for the first 8 maps for Planetary Probe. With the addition of engines in the Spaceship Commander game (where on each turn after launch, the engines can create thrust in any of 8 different directions or not at all), there can be a myriad of correct solutions for each puzzle, even for just a 10-turn game. Therefore, it is recommended that students be graded on correct completion of the Spaceship Commander puzzles, with potentially little or no weight given to their puzzle score.

Acknowledgements

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The names of the imaginary planetary systems in the provided maps are based on mythological beings associated with the sky, sun, moon, and stars. You can learn about these gods and goddesses by exploring the mythology section of *Windows to the Universe!* at:
http://www.windows.ucar.edu/

This activity was inspired in part by the 1978 board game ***Mayday***, by Game Designers Workshop (GDW), where players engage in spaceship combat. ***Mayday*** was designed by Marc Miller and won the Charles Roberts Award for the Best Science Fiction Game of the Year, but GDW is out of business and the game is out of print.